ACE Architecture, City and Environment

E-ISSN 1886-4805

Modeling Land Value in Peripheral Metropolitan: An Empirical Study in Jakarta Metropolitan Area

Citra Fadhilah Utami [1] | Kosuke Mizuno [2] | Hayati Sari Hasibuan [3] | Tri Edhi Budhi Soesilo [4]

Received: 2021-05-28 | Final version: 2021-10-12

Abstract

The purpose of this work is to map and examine infrastructure development and facilities on the land value both economically and spatially. The study used iso-value line analysis to describe land price increases in two decades (2000-2010), hedonic pricing models to determine how variable influences land price increases and Geographically Weighted Regression to describe spatial heterogeneity and spatial dependence. The results showed that the variable location of land located in cluster housing, proximity to the Station, proximity to the bus terminal, and proximity to toll gates became the main factors influencing land prices. These findings suggest that periphery and central transport connectivity are a consideration in pricing. The need for mass transportation as a consideration in the selection of homes in periphery area communities. These findings can help policymakers direct and control the spatial structure of regional economic development and policies related to land value capture.

Keywords: Geographically weighted regression; hedonic price model; iso-value line; periphery

Citation

Utami, C. *et al.* (2022). Modeling Land Value in Peripheral Metropolitan: An Empirical Study in Jakarta Metropolitan Area. *ACE: Architecture, City and Environment, 16*(48), 10631. DOI: http://dx.doi.org/10.5821/ace.16.48.10631

Modelado del valor del suelo en la periferia metropolitana: un estudio empírico en el Área Metropolitana de Jakarta

Resumen

El propósito de este trabajo es mapear y examinar el desarrollo de infraestructura y las instalaciones sobre el valor de la tierra, tanto económica como espacialmente. El estudio utilizó un análisis de línea de iso-valor para describir los aumentos del precio de la tierra en dos décadas (2000-2010), modelos de precios hedónicos para determinar cómo la variable influye en los aumentos del precio de la tierra y la regresión ponderada geográficamente para describir la heterogeneidad y la dependencia espaciales. Los resultados mostraron que la ubicación variable de los terrenos ubicados en viviendas agrupadas, la proximidad a la estación, la proximidad a la terminal de autobuses y la proximidad a las puertas de peaje se convirtieron en los principales factores que influyen en los precios de los terrenos. Estos hallazgos sugieren que la conectividad del transporte central y periférico es una consideración en la fijación de precios. La necesidad de transporte masivo como consideración en la selección de viviendas en comunidades de la periferia. Estos hallazgos pueden ayudar a los formuladores de políticas a dirigir y controlar la estructura espacial del desarrollo económico regional y las políticas relacionadas con la captura del valor del suelo.

Palabras clave: Regresión ponderada geográficamente; modelo de precios hedónicos; línea de iso-valor; periferia

[1] School of Environmental Science Programme, University of Indonesia (ORCiD: 0000-0003-0586-8696; WoS ResearcherID: 4186858); [2] School of Environmental Science Programme, University of Indonesia (ORCiD: 0000-0002-7411-8074); [3] School of Environmental Science Programme, University of Indonesia (ORCiD: 0000-0002-5728-2120; WoS ResearcherID: 4204874); [4] School of Environmental Science Programme, University of Indonesia (ORCiD: 0000-0002-3188-5812; Scopus Author ID: 57193915879). Contact e-mail: citra.fadhilah@ui.ac.id

E-ISSN 1886-4805

1. Introduction

Significant economic growth in urban areas forms metropolitan areas. This development also brings spatial transformation both in the city's core area and in the periphery area. This periphery area was formed due to the migration of residents at the city's core to the countryside in search of a better environment (Utami *et al.*, 2017). The development of this periphery, widely known as peri-urbanization, is a challenge for planners in developing countries, especially in Southeast Asia (Mazzocchi *et al.*, 2017; Winarso *et al.*, 2015). The periphery's development impacts increasing land value so that spatial transformation occurs (Kuusaana & Eledi, 2015). Understanding the mapping and valuation of land values in periphery areas can be the basis for planning space structures and the region's optimal economic development.

The Jakarta metropolitan area (JMA) has developed very rapidly in more than 40 years with a lot of investment (Hasanawi & Winarso, 2018). This development is very massif where private developer investment can turn more than 30,000 ha of rural land into new settlements (Winarso *et al.*, 2015). With the growth of this periphery area, the government supports the development of the road infrastructure backbone so that the area grows to follow this main road (Mcgee, 2009). To build connectivity periphery area with the Jakarta city, the government also built mass transportation based on buses and trains. Then with the increasing population and economy, education, health, and trade facilities are increasing. Infrastructure and facilities development is the main factor in the increase in land prices in the JMA periphery (Ichwan *et al.*, 2011; Rosa-Jiménez & Nebot, 2021).

In this paper, the purpose is to map and examine the effect of infrastructure development and facilities on the land value both economically and spatially. Although attributes that affect land values are very complex, this study seeks to capture those attributes' influence. Mapping land prices and how many factors affect them is critical in shaping the city's morphology and directing its structure and pattern. Land value can reflect the structure and economy of the city (Shatkin, 2016). The research's novelty is the integration between transportation modes that makes land prices increase in Jakarta

This paper begins by reviewing literature relevant to the factors that affect land value in the Periphery Area. The analysis in this paper consists of three stages. It was first mapping the market land price time series using iso-value line using market price data obtained directly from the environmental authority or community harmony and data from property agents in Depok. Second, examine the effect of infrastructure and facilities attributes on land prices using the hedonic price model. The latter captures the influence of the previous land attribute spatially by using Geographical Weighted Regression.

2. Literature reviews

The first generation of land value mapping focused primarily on soil fertility and distance costs incurred to get to work. This includes issues on the distance to the market Adam Smith (1776), (Wolloch, 2020). Then, the development of the agricultural land allocation model initiated by Von Thunen (1826) mentions the role of distance to the market that determines the commodities to be planted (Walker & Homma, 1996). Many researchers later developed this theory, including Alonso (1964) with bid-rent theory (Arnold *et al.*, 2017; Brueckner, 2013). Commercial land use will tend to be close to the city center, close to the market. Simultaneously, industrial land use will tend to stay away from the city center because of the high rent of downtown land, while the need for industrial estates is more on large land and cheap labour.

E-ISSN 1886-4805

This theory states that land prices will be higher when closer to the city center, although not directly proportional to profits. This theory is the basis of land theory in urban areas.

This land lease theory was then developed through the burgess urban structure model (1925) (Tione & Holden, 2020). This model describes ideal land use patterns and urban social structures with a strong emphasis on residential areas. The importance of sectoral development was taken by Hoyt (1939) (Drake *et al.*, 2020) in his study of housing rental rates in major American cities. Hoyt stated that direction and distance from the city center became important in land use. The debate relating to the theories says that land value is related to proximity to the city center and various physical and socio-economic factors even related to politics. The literature illustrates different views on mapping land value. Many authors are concerned with transportation development Railway, high-speed rail on transit-oriented development (Arum & Fukuda, 2020; Dziauddin, 2019; Sharma & Newman, 2018), the existence of bus-based mass transportation and port area (Forte, 2016).

The increase in land prices around the railway can reach 278%. Research is also concerned with providing infrastructure and land ownership status that plays the most role in increasing land value (Hasanawi & Winarso, 2018). The dynamics of land prices in Metropolitan Jakarta are influenced by land banking practices by some large-scale land rulers (Elmanisa *et al.,* 2016). Some researchers also concern about physical attributes: land use, environment, population, and land value theory (Sly & Tayman, 1980).

Physical attributes here include location quality, topography, climate, water availability, sewerage. The more facilities associated with land, the higher the land price. Another topography has a direct effect on construction costs and, thus, overall development costs. Facilities developed on uneven land will have a much higher cost than flat land (Sharma & Newman, 2018). Studying the benefits of land value can also be a source of infrastructure financing and government revenue (H. S. Kim *et al.*, 2019). Some are concerned that social-economic land value is related to population density (Lavee, 2015). Environmental disamenities lower land prices (Lee *et al.*, 2021). Differences in power, market and administrative policy, public land ownership, and private land ownership. Market or planned approach. Time, differences in stakeholder perspective, space perspective, and time perspective are also considered in land value (Lu *et al.*, 2018).

Enemark (2004) argues that land information is an engine to land administration and overall societal growth (Mitchell *et al.*, 2015). In Ethiopian reality, peri-urban land interventions are, however, hardly supported by appropriate land information. One Land value is directly and closely related to the decreasing land, more related to land status (Kuusaana & Eledi, 2015). The counter-arguments assert that land status affects land value in many developing countries (Tione & Holden, 2020). Others hold a different view, arguing that policy influences land speculation (Melián-Alzola *et al.*, 2020). Land use control has a positive, negative, or neutral impact on urban land value (Boamah, 2013). Migration policy, urbanization affects the disperse of house prices said that land price dynamics are more influenced by macroeconomics such as inflation. Because it is complex, land assessment in developing countries can use Big data with distance, point of interest, demographics, housing, economic, education, and social. Using Big data, location-based land value mapping in metropolitan Washington dc is more dynamic (Davis *et al.*, 2017).

2.1 Periphery area

An essential part of this study also explores the increase in land value in periphery areas. The periphery area is part of the Metropolitan Area. The Metropolitan concept was introduced in early 1910 with the term metropolitan district (García-Hípola, 2021; Shi & Cao, 2020). A concentration of residents in an area shows the core area and its periphery, called the periphery (Sly & Tayman, 1980).

E-ISSN 1886-4805

The movement of residents, worker structure, and economic structure between the core and periphery indicate a close relationship both economically and spatially (Tuppen, 1986).

Various studies have been conducted in metropolitan areas, in general, do not explicitly suggest a shift in the value of land in the suburbs(Enfoque et al., 2019). On the other hand, the exploitation of the periphery environment in accommodating the urban development of both the population and the economy brings various conflicts (Vij *et al.*, 2018). Priphery area has different characteristics from this city. The value of land in the Periphery Region is growing in its connectivity to the core city and depends on the region's economy and politics (Shatkin, 2016).

2.2 Land value

The literature suggests that the use of hedonic pricing in determining the value of sensitive land to find the factors that influence it (M. Kim, 2020). But some critics also point out that hedonic pricing cannot spatially map the factors that affect land value (Dziauddin, 2019). Thus, currently developed research tools that can map spatial interactions. Land values may vary by geographical area can be mapped using Geographically Weighted Regression (GWR) (Han *et al.*, 2020; Song *et al.*, 2020).

In recent research, several main factors have become the focus of research. Most are interested in examining the influence of mass transportation such as trains and buses (Tsutsumi *et al.*, 2011). Further attention to classic factors such as proximity to the market and CBD (M. Kim, 2020; Sathita Malaitham *et al.*, 2020) remains the primary consideration of land value increase in the Metropolitan Area. Environmental and comfort factors are also factors considered in determining metropolitan land value (Ardiwijaya *et al.*, 2015) Table 1 describes some empirical studies on mapping the dynamic value of land in metropolitan areas. This empirical study can describe research related to the value of land in the Metropolitan Area.

Table 1. **Synthesis of selected land value studies in metropolitan areas**

City/Author	Attribute	Method	Finding	Impact
Bangalore (Sharma & Newman, 2018)	Metro rail	Hedonic price model	Metro rail is substantial in both periphery area and the whole city	4.5% City wide price increase
Bangkok Metropolitan (S Malaitham *et al.*, 2020)	Near Station, distance to the main road, distance to Central Business District (CBD) and shopping mall	Hedonic Price model	The results show that the determinants of property value are myriad and varied over space, i.e., spatial non-stationarity exists in the study area.	Price increase 0.777% proximity to main roads
Metropolitan City of Naples, Italy (Forte, 2016)	Real estate investment	Descriptive	Effect of land price increase on Port Area	Land value is growing thoroughly in the Metropolitan Area
Greater Kuala Lumpur (Dziauddin, 2019)	Proximity to the CBD, proximity to schools, proximity to markets, and proximity to stations	Hedonic Price and GWR	Proximity to the CBD, proximity to schools, proximity to markets, and proximity to stations	proximity to the nearest light rail transit station gives favorable premiums of up to 8% for most properties located in lower-middle and upper-middle income neighborhoods
Tokyo Metropolitan Area (Tsutsumi *et al.*, 2011)	Distance to Station	geographically weighted	accessibility to the center of the area is an explanatory variable	Areas that are accessible by train have a high increase in land

E-ISSN 1886-4805

	Population density Area of land use	regression (GWR) kriging	for the land price model.	
Tokyo Metropolitan Area (Arum & Fukuda, 2020)	Distance CBD, building coverage ratio (BCR) defines the maximum ratio of land permitted to be developed, while floor-area ratio (FAR) defines the maximum ratio of the total area of floor space permitted to be developed	multilevel mode contextual clustering	variations in residential land values, making up 66% of variance partition in the variance component model and 70% of variance partition in the random intercept model for single line membership.	The interrelationship of the city's core mass transportation and periphery came first
Metropolitan USA (Li *et al.*, 2016)	accessibility, proximity externalities, amenities, environmental conditions, air pollution, and land-use info	ordinary least squares (OLS) regression	air pollutions and the lack of forest coverage have and detrimental effect on housing values over time.	The environment becomes an essential factor in the value of land
Seoul metropolitan (B. Kim & Kim, 2016)	Land use, Altitude, Landform, Contact with the road, distance from railroad, distance from waste treatment facilities, Big projects	SEM (Spatial Error Model) with OLS	Factors in urban development	The need for spatial statistical models to estimate official land prices
San Francisco Metropolitan (Kok *et al.*, 2014)	Distance to CBD, job accessibility, regulation	Regression	Land use varies to local regulation	The policy of determining the function of the region to form the value of land
China (Han *et al.*, 2020)	the empirical research into land-use regulation has mainly addressed its significant effects on the housing market	System GMM estimation	the construction land quota, constraints on the allowed floor area ratio (FAR) of each land transaction parcel, and land supply restrictions	the intensive use of urban land allocation by improving the quota volume

Source: (Arum & Fukuda, 2020; Dziauddin, 2019; Fabian Forte, 2016; Han *et al.,* 2020; B. Kim & Kim, 2016; Kok *et al.*, 2014; Li *et al.*, 2016; Sathita Malaitham *et al.,* 2020; Sharma & Newman, 2018; Tsutsumi *et al.,* 2011).

Based on previous research in table 1, this research that will be sub-variable and indicators that affect land value consists of 12 dependent variables that affect land value, namely land status, water availability, neighbourhood comfort, close to market, close to the central business district (CBD), close to school, close to Station, close to health facilities, close to the bus terminal, close to toll door, close to the road and close to secure. . And one variable that distinguishes it from other studies that characterize the value of land in metropolitan developing countries is the presence of land in clustered housing managed by private developers with organically growing housing.

E-ISSN 1886-4805

This feature becomes one of developing countries' metropolitan characteristics with a mixture of rural and urban features in the Metropolitan Area (Mcgee, 2009).

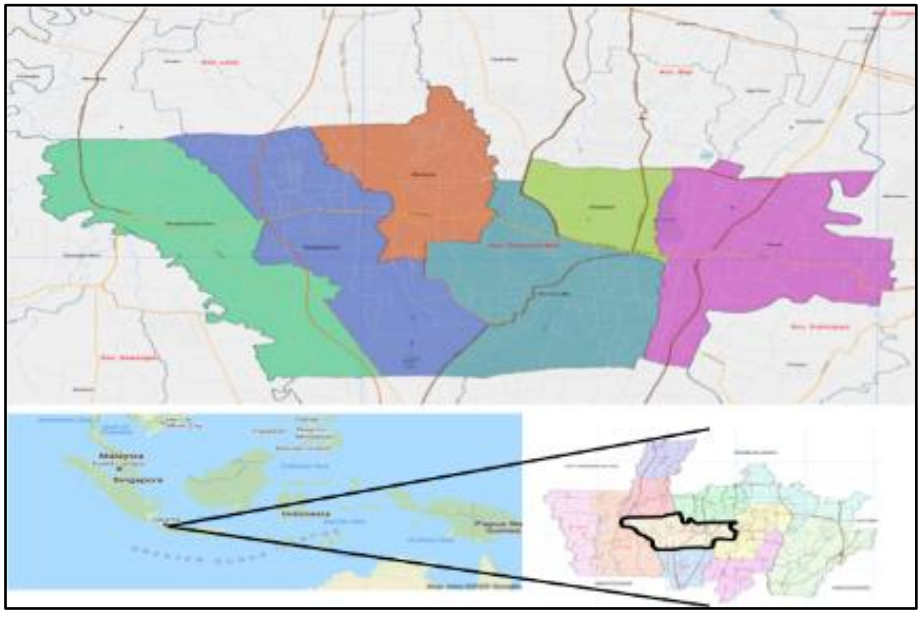
In recent research, several main factors have become the focus of research. Most are interested in examining the influence of mass transportation such as trains and buses (Tsutsumi e*t al.*, 2011). Further attention to classic factors such as proximity to the market and CBD (Sathita Malaitham *et al.*, 2020), remains the primary consideration of land value increase in the Metropolitan Area. Environmental and comfort factors are also factors considered in determining metropolitan land value (Ardiwijaya *et al.*, 2015).

3. Methods

3.1 Study area

Jakarta has been the most densely concentrated metropolitan in South East Asia (Nascimento *et al.*, 2018). It is among the largest trade nodes in Asia, with the manufacturing sector playing a significant role nationally and internationally, led by rapid urbanization (Winarso *et al.*, 2015). With its rapid economic growth, JMA became Indonesia's key gateway to the global economy (Winarso *et al.*, 2015) There are Jakarta, Bogor City, Depok City, Tangerang City, Tangerang Regency, Bekasi City, and Bekasi Regency. In this research, Depok city was chosen as the periphery area in Jakarta Metropolitan Area. Depok city can represent a rapid change in non-urban land use to urban (Hasanawi & Winarso, 2018). To describe the increase in land value specifically, the Pancoran Mas subdistrict was chosen in Figure 1 as the location of research details.

Figure 1. Study area (Depok City, West Java Province in Indonesia)



Source: (Hasanawi & Winarso, 2018)

The geographical location of Pancoran Mas Subdistrict is very strategic, which is in the middle of the urban heart of Depok city surrounded by people's houses and shopping canters, shops, and offices and places of worship. Pancoran Mas subdistrict has an area of ± 18.04 km², with the height of the area from sea level about 50 to 60 meters with a relatively flat and hilly land surface. Based on the

E-ISSN 1886-4805

economic structure, the leading potential of Depok city area is the tertiary sector which includes the trade sub-sector, hotels and restaurants, and the service sub-sector. The population of Depok according to the census in 2014 reached 2,033,508 peoples, consisting of 1,025,784 men and 1,007,724 women. The gender ratio between men and women in Depok is 101.79. Cimanggis subdistrict is the most populated compared to other sub-districts in Depok, which is 283,025 people while the sub-district with the smallest population is Limo Subdistrict. The location of Depok city is very strategic when viewed in terms of politics, economy, socio-culture and defence and security because it is directly adjacent to the capital city of Jakarta as the canter of government and economy. Depok city serves as a buffer area of the capital city of Jakarta so that everything that happens in Jakarta will have a direct or indirect impact on the city of Depok. In accordance with Presidential Instruction no. 13 of 1976 on the development of JABODETABEK Area, Depok which is part of Bogor Regency in the past was directed to be a residential area, but in its development Depok city not only became a comfortable residential place but also developed into a city of trade, services, and education.

The economic sector that has growth and contribution to regional income and high absorption of labour is the most superior sector among the existing economic sectors. This sector will be the main driver of the economy in a region. The economic structure of Depok is dominated by the trade sector, hotels, and restaurants with a distribution of 37.38% in 2019. The strategic development plan includes aspects of improving facilities and infrastructure, aspects of human resource development management, and financial aspects.

Based on initial observations obtained input from the spatial planning section, regional revenue agency Depok city that Pancoran Mas Subdistrict, Depok City is a sub-district with land problems, and the value of land that varies from changing green zones to housing, congestion, being on the mainline of Depok City, as well as the influence of commercial activities on land values. Pancoran Mas sub-district is the centre of Depok city's growth with the existence of a government centre, the existence of stations, bus terminals' existence, and the existence of new toll gates. This is expected to represent various factors that affect the soil's value in the modelling of the soil value to be compiled.

3.2 Estimated increase in land value

This paper combines iso-value line analysis, hedonic pricing model, and GWR method in describing land value increase. The iso-value line can spatially describe the increase in land prices based on land use distribution and infrastructure to capture important factors that affect land prices. The Hedonic pricing model captures the "willingness to pay" for various residential land attributes, namely structural, locational, and neighbourhood attributes, by measuring how buyers buy a home at a specific price with the best combination of those attributes. The GWR method considers spatial and spatial dependence diversity by measuring geographic coordinates as parameter estimates and intercepts.

The hedonic pricing model is a technique that is widely used to analyse the value of one commodity with different characteristics. This technique was developed to assess the price that occurs in the market with regard to its characteristics. On land purchase, characteristics are considered structural characteristics such as ownership status, availability of clean water, locational characteristics such as proximity to various educational or health facilities, proximity to transportation facilities, and socio-economic characteristics such as environmental comfort and racial composition.

Previous research that a hedonic pricing model is a powerful tool in estimating land prices (Tione & Holden, 2020). However, the hedonic pricing model was criticized for assuming that the variable is dependent and independent homogenous. Geographically, there is every plot of land with a

E-ISSN 1886-4805

heterogeneous spatially. Although many past hedonic pricing studies attempted to control for spatial effects by increasing the sample size, including locational and socio-economic attributes, measuring proximity from a given residential property to amenities with distance, and applying a hedonic pricing model to housing submarkets or different types of properties, the nature of the spatial relationship between residential property prices and attributes has not been explicitly modelled (Dziauddin, 2019).

Compare to the hedonic pricing model, where single variable calculations are implemented throughout the whole geographical area, GWR is an explorative approach that enables differences in relations between dependent and independent variables over a geographical area to be calculated on a single modeling system. This will offer a means to accommodate the geographical sense within which land units are situated (Azhdari *et al.*, 2018). GWR's process illustrates spatially different relationships in the mapping of a sequence of model parameters where the local area is characterized by spatial kernel functions with fixed or fluctuating bandwidth. This paper intends to use the hedonic price model in a novel way to explore and model spatial variations in land value uplift around light rail transit stations. In building hedonistic pricing models, GWR is used to calibrate location regression parameters by weighting the location between one data point to another through coordinated data. By entering longitude and latitude coordinate data (xi, Yi), a common form of double-log hedonic pricing model was established in this study with the mathematical equation 1.

$$\ln Yi = \beta (xi, yi) + \sum \beta k (xi, yi) \ln xik + \varepsilon i \qquad (1)$$

Where lnYi is the log dependent variable at position I lnxik is the log factor of the kth explicative variable at location I β0 (U.I., vi) is the intercept variable at position I βk (xi, Yi) is the localized regression coefficient for the kth explicative variable at location I (xi, Yi) is the coordinate of position I and ɯi is the random error at location i. Remember that the same log is used to enable interpretation of the coefficient and is the estimated percentage change in the dependent variable for a percentage change in the independent variable. A double-logarithmic process has been chosen because it is usually ideal for the R2 criteria and is intuitively interpretable. Focused on the equation (1) above, the location-specific parameters βk (U.I., v I am calculated using the least square weight and can be described as equation 2 (Dziauddin, 2019).

$$\beta (xi, yi) = (XT W (xi, yi) X) - 1 XTW(xi, yi) y \qquad (2)$$

In which β (xi, Yi) = β0 (xi, vi), ..., βn (xi, vi) is the vector of the local regression coefficients, X is the function of the explanatory variables with column 1s for intercept, y is the vector of the dependent variables, and W (xi, vi) is the diagonal vector symbolizing the relative geographical weight of each information for regression point i. By this geographically weighted calibration, the constant and smoother surfaces of the local parameter estimations can be mapped over a geographical area.

3.3 Data acquisition

This research provides benefits in estimating the benefits of land value development and capturing the spatial transformation of land development to be planned and controlled correctly. Knowing the potential increase in land value will direct economic development policy and related to land value capture. The research's novelty is the integration between transportation modes that makes land prices increase in Jakarta and methods used by combining hedonic pricing models and Geographical Weighted Regression (GWR).

The iso-value line describes the land price of Pancoran Mas Subdistrict in the time series 2010 to 2020. The data used are primary data due to the lack of leaked data about the sale and purchase price of land. It is expected that prices in emerging markets differ considerably from those set by local governments.

E-ISSN 1886-4805

The data for this depiction is obtained by direct survey on landowners, data owned by local, regional authorities, namely from the community, and data obtained from property agents in Depok. The land price pictured is the price of land per square meter. Currently, the land in Depok is mostly dominated by residential, commercial, and industrial areas and green zones, but the focus of this research was on residential and commercial areas. The study area was narrowed to Pancoran Mas Subdistrict, which has been reported to be the most densely with multiple land-use problems and mainly dominated by commercial and residential as shown in Table 2.

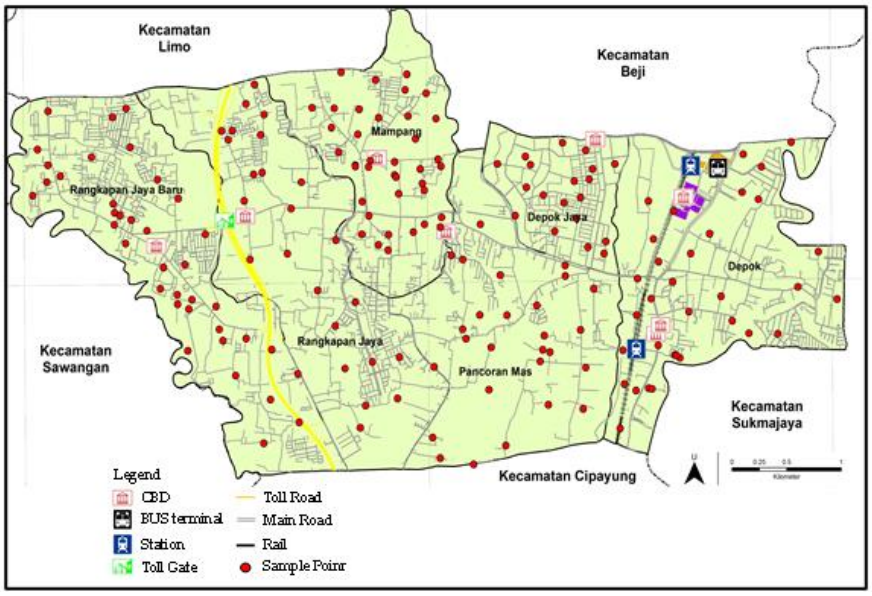
Table 2. Land Parcel of Depok City, 2019

Classification	Green Zone	Residential Area	Industrial Area	Commercial Area	Total Number of Parcel
Parcel (%)	892	28.529	8.024	7.132	44.577

Source: (Paramitadevi, 2020).

This, therefore, means on these two areas. The survey is to be conducted from 18 August to 6 October 2020 to determine the value of residential and commercial land within Pancoran Mas Subdistrict's boundaries in Depok city. Isaac and Michael's method were used to determining the 183 land parcels depicted in Figure 2.

Figure 2. Distribution of sample point



Source: https://www.researchgate.net/figure/Land-use-of-Depok-City_fig3_318279580/download

They were used as samples with a 0.1 margin of error. The median land values are projected to be determined by interviewing landowners and seeking their appraisal using specific characteristics.

3.4 Model requirement

To estimate land value uplift around light rail transit stations, this paper uses a double-log specification, and its final form can be written as equation 3.

$$LnYi = \beta 1 LnSTATUSi + \beta 2 LnWATERi + \beta 3 LnNEIGHBORHOODi + \beta 4 LnCLUSTEREDi + \beta 5 LnMARKETi + \beta 6 LnCBDi + \beta 7 LnSCHOOLi + \beta 8 LnSTATION + \beta 9 LnHEALTHi + \beta 10 LnBUSi + \beta 11 LnTOLLi + \beta 12 LnTOLLi\, \varepsilon i \quad (3)$$

E-ISSN 1886-4805

Where Yi is the sold price of land in Indonesian currency; Ln is the natural logarithm; STATUS is the status of land tenure; WATER is a condition of water availability; the neighbourhood is the comfort of the environment; CLUSTERED is the location of land whether in clustered community or formal housing; MARKET is proximity to the market; The CBD is the proximity of the centre of government and commerce; School is proximity to the school, Station is proximity to the train station, HEALTH to health facilities, BUS is proximity to the bus station, and TOLL is proximity to the toll gate.

4. Results and discussions

Data on the base map, land parcel, and land use were obtained from the land map, Ministry of Agrarian and Spatial Affairs / State Land Agency, Indonesia. The data are believed to be of high quality and reliability as these data come from the professional body that provides maps and land use data in Indonesia. To measure the distance for a given observation to the locational amenities, the geographical information system (GIS) was used to position each observation accurately on a local map using geographical coordinates (latitude and longitude) obtained from Google Maps. Process of determining geographical coordinates from Google Maps. GIS and spatial analysis were implemented into this paper, and inclusion was highly important because the land's closeness to the location attributes was evaluated precisely by using network distance. In this study, variable related to the location is Close to MARKET, Close to CBD, Close to SCHOOL, Close to STATION, Close to HEALTH facilities, Close to Bus, Close to TOLL door, Close to ROAD and Close to SECURE.

Table 3 provides the conclusions of statistic dependent and independent variables used in this paper. For example, land prices range from 1.5 million rupiahs per square meter (US$107.11 at a dollar price of Rp 14,004.50 in 2020) to a price of 20 million rupiahs per square meter of land (US$1428.11). The mean land price on the sample is 4.5 million rupiahs (US$ 321.33).

Table 3. Results statistic descriptive variable

	Unit	Mean	Standard Deviation
Land (Y)	Rupiah	4.8033	2.80983
Water	Dichotomous variable	.9617	.21904
Neighborhood	Dichotomous variable	.8525	.37075
Clustered	metre	.5301	.68574
Market	metre	1878.6885	1332.52525
CBD	metre	3984.4262	2451.05731
School	metre	1463.5738	743.59696
Station	metre	4195.3279	1306.79339
Health	metre	4682.1421	1511.72019
Bus	metre	3819.8798	1566.35070
Highways	metre	2736.0656	1134.20100
Road	metre	527.2678	431.58304

Source: The results of the research data were processed with SPSS 26.0.

It is reasonable to assume that the standard error is not heteroscedastic. Since the GWR approach represents a new concept, it is rational to predict multicollinearity among the variables calculated in the GWR model.

Wheeler & Tiefelsdorf, (2005) multicollinearity seems to be more likely to be observed in GWR models than in hedonic pricing models. Furthermore, Wheeler & Tiefelsdorf (2005) argues that: evaluating GWR data for local multicollinearities and pair-wise correlations among sets of local coefficients becomes even more crucial than in the conventional management regression model increasing

E-ISSN 1886-4805

complexity of the GWR estimation process, which eventually lead to cross-relation among local estimates. To resolve this, it is recommended that graphs of pairs of local parameter estimates should be conducted to evaluate the prevalence of local multicollinearity.

The presence of local multicollinearity was first detected in this paper using Pearson's correlation coefficient and supported by scatterplots; no significant multicollinearity between pairs of local parameter estimates was found.

Normality tests show normal distribution data if the value of Z statisitc is below Z table (Ztable=1.96) and significance above 0.05. In the results of the normality test above shows the value of Z statistic is 1,987 and significance 0.007 so that the value of Zhitung above Ztable (Ztable = 1.96) and significance above 0.05 can therefore be interpreted that the data in this study is normal distribution.

The multicollinearity test aims to determine if there is a high relationship between independent variables. There is no multicollinearity problem if the Tolerance value is above 0.1 and the VIF is below 10. The result above (Table 3) shows the Tolerance value of each independent variable is above 0.1 and VIF below 10 so it can be said that there is no multicolerity, meaning there is no high relationship between independent variables.

Heteroskedastisitas test is a test that aims to test whether in a regression model variance inequality occurs from residual to another observation.

The above result obtained significance value in some variables that are above 0.05 so that there is no heteroskedastisitas, namely X1. Ownership Status, X2. Water Availability, and X3. Environmental Quality, X7. Distance to Educational facilities, and X12. Distance to collector's road. While there are seven variables whose significance value is below 0.05 namely X4. Housing Cluster, X5. Distance to economic activity, X6. Distance to government center, X8. Distance to health facility, X9. Distance to station, X10. Distance to bus terminal, X11. Distance to the toll booth.

4.1 Land value mapping

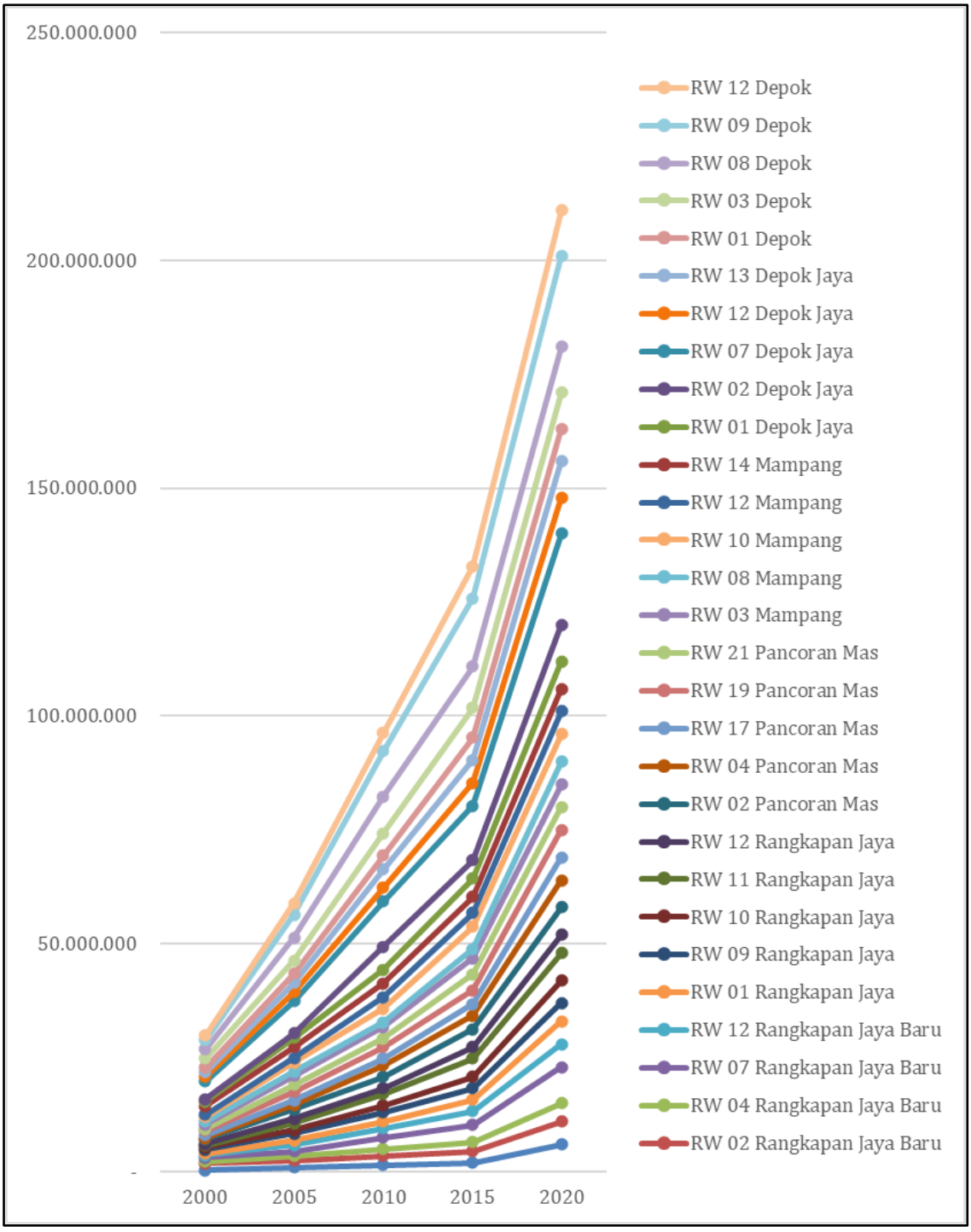
Based on the primary data obtained, the increase in land value in Pancoran Mas Subdistrict occurs very significantly and consistently seen in Figure 3.

Land prices continue to rise throughout the region. Depok and Depok Jaya subdistricts experienced the highest increase, while Rangkapan Jaya Baru Village experienced the smallest increase. Pancoran Mas sub-district is the sub-district with the highest percentage increase. Figure 4 depicts the spatial spread of land prices in two decades 2000-2020.

In 2020, the highest price of land in the range of 3.5 million rupiahs per square meter (US$249.92) was in the Depok Jaya area. Ten years later, this price rose to two to three times the highest price of land, 9.5 million rupiahs (US$678.35) located in the Depok Jaya Area and then spread in the Depok area. In 2020 the increase in land prices was also spreading with peak prices far above the surrounding area; Depok Jaya and Depok remain soaring with a maximum price of 19 million rupiahs (US$1356.71). The development of new land price peaks will begin to form in the Rangkapan Jaya Baru area is expected due to the presence of toll roads in this area.

E-ISSN 1886-4805

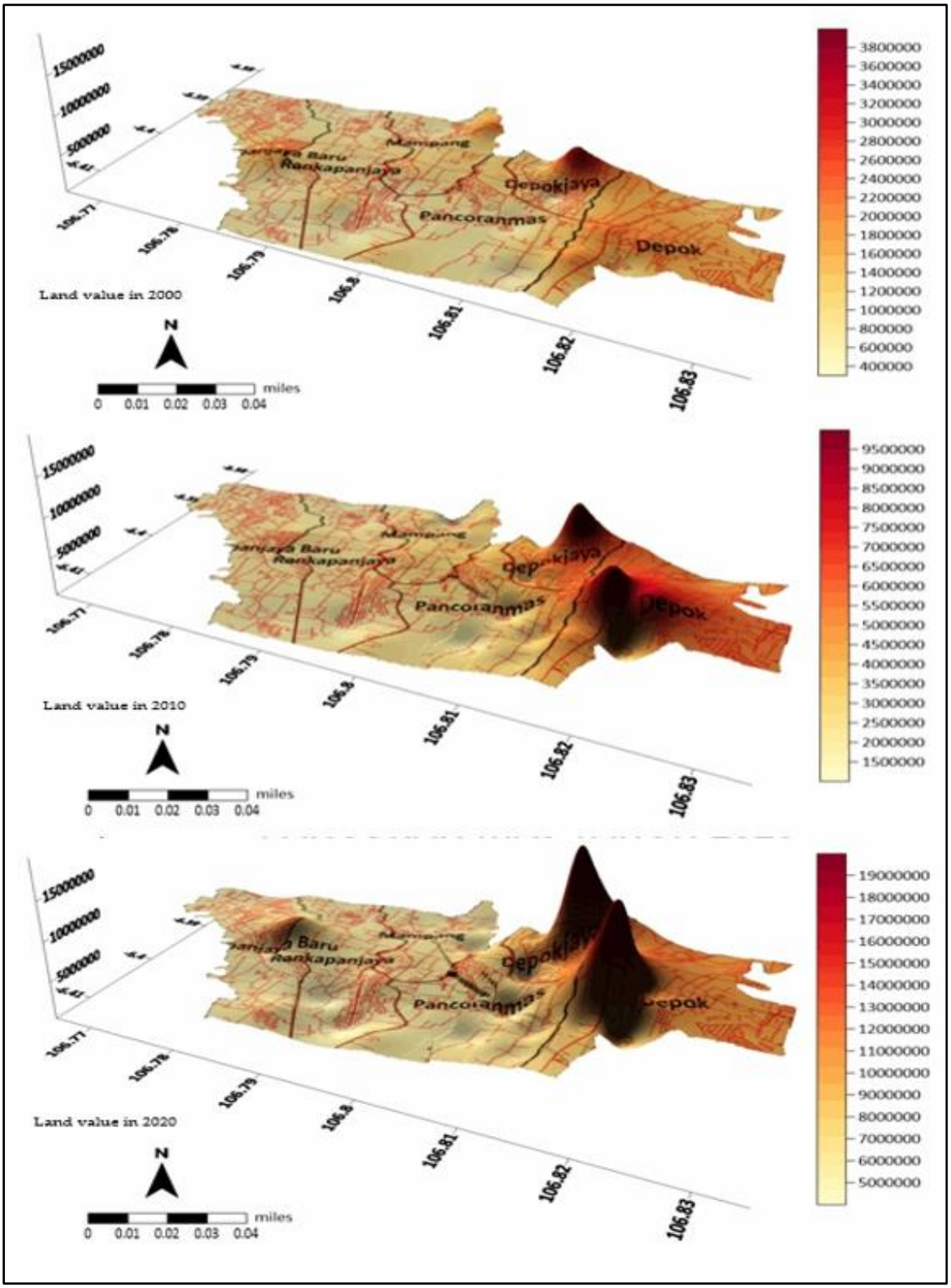
Figure 3. Land Price Increase in Pancoran Mas Subdistrict



Source: http://panmas.depok.go.id/aset-kecamatan/2021/03/1-Renstra-Kec.-Pancoran-Mas-2020

E-ISSN 1886-4805

Figure 4. Iso-value line land value of Pancoran Mas subdistrict in 2000-2020



Source: http://panmas.depok.go.id/aset-kecamatan/2021/03/1-Renstra-Kec.-Pancoran-Mas-2020

E-ISSN 1886-4805

4.2 Hedonic Pricing Models

The hedonic pricing model contains a standard set of predetermined estimates, and this single value is implemented across a geographic location. In another way, the GWR model provides a local parameter calculation of each measurement area that contains minimal peak value. Table 4 presents the outcomes for the hedonic price model and the GWR projections.

Table 4. Hedonic pricing model and GWR results (n=183)

	Ordinary Least Squar				GWR		
	β	t-ratio	Sig.	VIF	β		
					Min	Max.	Min.
Intercept	12.693	9.026	.000		12,332	14,214	12,843
Status	.364	.522	.602	1.032	-0,101	0,633	0,096
Water	-.503	-.833	.406	1.981	-0,595	-0,445	-0,555
Neighbourhood	-.134	-.257	.797	1.642	0,172	0,659	0,2853
Clustered	.936	3.858	.000	1.227	0,218	2,137	1,623
Market	-1.335E-5	-.017	.987	50.206	-0,000	0,114	0,024
CBD	.000	-.239	.812	171.784	-0,000	0,114	0,024
School	.002	.519	.604	244.897	-0,456	0,002	-0,097
Station	.000	-1.979	.049	2.344	-0,001	-0,000	-0,000
Health	-.001	-5.522	.000	3.180	-0,001	-0,001	-0,001
Bus	-.001	-2.737	.007	3.691	-0,001	-0,000	-0,001
Highway	-.001	-3.029	.003	2.020	-0,001	-0,000	-0,001
Road	-.001	-1.450	.149	1.102	-0,001	-0,000	-0,000

Notes: Goodness of fit: Adjusted R^2 = 51,98 (hedonic pricing model); Adjusted R^2 = 58,92 (GWR).
Source: The results of the research data were processed with SPSS 26.0.

Regression results show that 51.5% of variance dependent variables can be described and related. This is due to the many other factors that affect the value of the land. Based on the double-log specification, variable that influences the highest land value in Pancoran Mas Subdistrict, Depok City is the existence of land in clustered area of formal housing, proximity to the Station, proximity to educational facilities, proximity to bus terminals, and proximity to toll gates.

From the hedonic price model equation, the result shows that every 100 m away from the station or bus terminal, land prices will rise by 11.01%. The decrease in land price is estimated at 2.4 million rupiahs (US$ 171.37) each away from the Station. An exciting variable that affects the value of land is the presence of land in cluster areas or formal housing, this proves that the existence of formal housing significantly affects the increase in land prices in the surrounding area. Land in clustered housing has an impact on price differences of up to 14.8% is the highest percentage of significant variables that affect land prices. So, the existence of clustered housing or formal housing must be controlled both spatially environment.

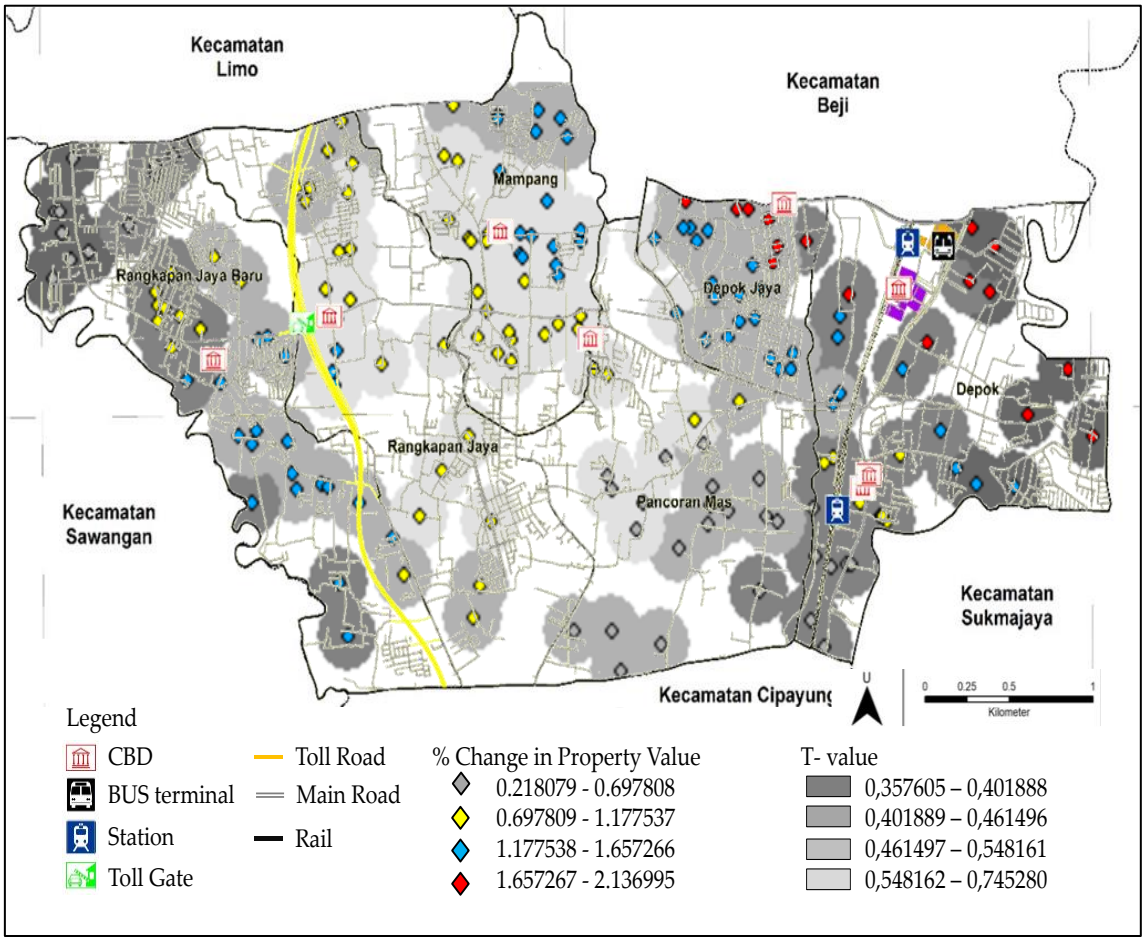
4.3 Geographical weighted regression

In discussing the hedonic pricing model before, housing in clusters, proximity to Station, proximity to health facilities, proximity to bus terminals, and proximity to toll doors became significant factors influencing land value. At this stage, GWR can generate estimates of the relationships of each location. Some software can do GWR analysis, but this paper will use GWR 4.0 built by Nakaya, Charlton, Brunsdon, and Fotheringham in 2009. In GWR 4 in this paper using Gaussian setting model, with adaptive calibrating bi-square spatial kernels that use narrow bandwidth with scattered data. This bandwidth selection greatly influenced the significant impact of the GWR results. To identify bandwidth options are used Aikake Information Criterion (AIC).

E-ISSN 1886-4805

In diagnostic, GWR obtained R2 by 58.93%. Although all local parameters on each table can be described, this paper will only discuss the influence of the three main variables: clusters, stations, and tolls. In Figure 5.

Figure 5. Map of the influence of estimation parameters on variable clusters



Source: https://www.researchgate.net/figure/Land-use-of-Depok-City_fig3_318279580/download

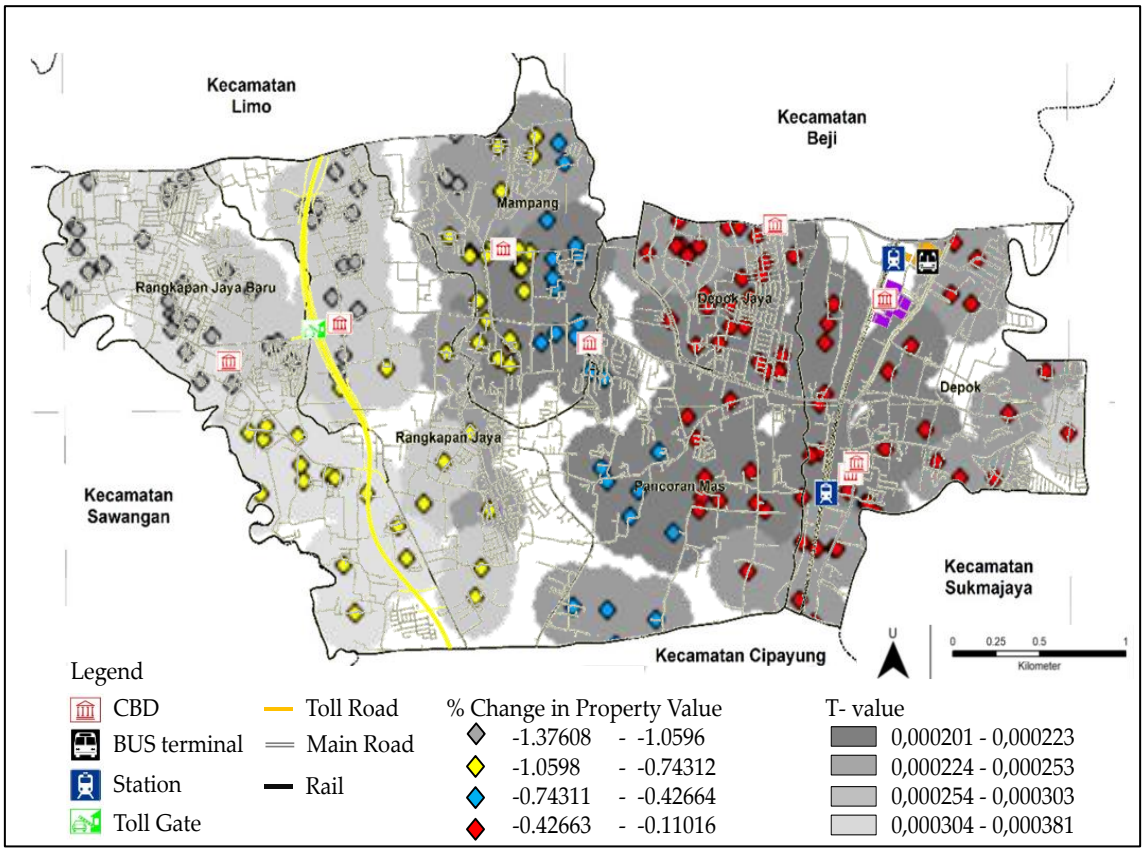
The influence of the location of land inside or outside clustered housing is spread over Depok, Depok Jaya, and Rangkapan Jaya Baru areas. In this area spread clusters of relatively new small housing that makes land prices increase around it. In Figure 6, the Station against the spatial value of land is in Depok, Depok Jaya, and Pancoran Mas.

This is because there are two stations in this area, namely Depok Baru station and Depok Lama. The existence of bus terminals in the Depok area should be considered in the increase in land prices. The effect of the Station's existence can increase up to 15% of the land price in the area.

While the Station's influence in Rangkapan Jaya and Rangkapan Jaya Baru is very low so that the price of land in this area is far compared to the area close to the train. It appears that the increase in land prices occurred in the Area Rangkapan Jaya Baru, as Pancoran Mas north and the northern part of Depok area. This indicates the existence of tolls impacts the increase in land prices, although on a smaller scale of 8%. This indicates that there will be a shift in land increase in Rangkapan Jaya Area, so that it should be anticipated the development of the region.

E-ISSN 1886-4805

Figure 6. Map of the influence of estimation parameters on station variables



Source: https://www.researchgate.net/figure/Land-use-of-Depok-City_fig3_318279580/download

Based on the influence of cluster variables, it appears that the deployment of small clusters occurs in regions with accessibility to both stations and toll doors. The development of this small cluster makes the increase in land prices irrational. The difference in land price in contiguous areas, but one land is on the other cluster, will be very high. This small cluster's development must be controlled considering that this small cluster does not provide adequate environmental infrastructure, let alone facilities such as playgrounds.

With the influence of the existence of stations, bus stops, and CBD, it is seen that the development of Depok city is currently centered on the eastern corridor, namely Margonda road. In this corridor, land price increases have occurred significantly over the past two decades. The concentration of investment and development makes this area the main center of Depok city. This has implications on the carrying capacity of the region.

This area will be the centre of congestion and environmental problems such as drainage and clean water. The government should anticipate the development of massif in this corridor. The utilization of integrated transit areas and land value capture can be a concern in this region's development. With the high significance of stations and buses affecting land prices in Depok, this can be an indication that periphery communities are in desperate need of mass transportation. With the majority of periphery residents working in Jakarta's core city, connectivity from the periphery area to the city is urgently needed.

E-ISSN 1886-4805

The shift in a land price increase in the toll gate area indicates that the JMA periphery community in Depok city still uses private vehicles to go to the core area. The increase in land prices due to toll access is significant. The government should consider new developments in areas with tollgate access to prevent uncontrolled development. The government should consider the new prime-sized area as a new growth centre to regulate spatial use.

5. Conclusions

Using the iso-value line, hedonic price model, and GWR in describing the influence of variables on land values in the JMA metropolitan periphery area provides comprehensive results. Variable that affects land value in this area is proximity to the Station, proximity to the bus terminal, then proximity to the canter of government, and toll road. This variable becomes an input in determining the value of land and the spatial structure of the region. The influence of toll doors is one of the new variables that affect land value in the metropolitan periphery area.

The increase in land value in Pancoran Mas sub-district occurred very significantly and consistently. In 2020, the highest price of land in the range of 3.5 million rupiah per square meter (US$249.92) is in Depok Jaya area. In the next ten years, this price rose to two to three times the highest price of 9.5-million-rupiah (US$678.35) land in Depok Jaya area and then spread to Depok area. In 2020 the increase in land prices is also increasingly spreading with peak prices far above the surrounding area, Depok Jaya and Depok remain soaring with a maximum price of 19 million rupiah (US$1356.71). The development of new land price peaks will begin to form in the Rangkapan Jaya Baru area is expected due to the presence of toll roads in this area.

The effect of the need for transportation access such as stations, buses, and tolls became the main thing in selecting residential locations for periphery residents. In contrast to the classic theory, proximity to the market becomes the main factor forming the region's structure. The findings of this study can estimate the increase in land prices on a variable. However, the degree of detail of the captured data should also be enlarged. The variables considered have also not been taken thoroughly relating to land physical, socio-economic and environmental. Therefore, further studies are needed, such as using big data and interview with the community directly. With regard to the limitation of cross-sectional data, future studies require panel data in capturing the impact of each variable on land values. Finally, the impact of variables in detail can be better when explained in relation to each level of community income.

Acknowledgements

This research was funded by University of Indonesia-International Indexed Publication (PUTI) 2020, number 626/SK/R/UI/2020.

Author Contributions

The first author conceptualizes, designs research, collects data and writes papers; the second author analyzed the data; the third author determines the research methodology of the paper, and the fourth author corrects and provides suggestions.

Conflict of interest: The authors declare that they have no conflict of interest.

E-ISSN 1886-4805

Bibliography

Ardiwijaya, V. S., Sumardi, T. P., Suganda, E., & Temenggung, Y. A. (2015). Rejuvenating Idle Land to Sustainable Urban form: Case Study of Bandung Metropolitan Area, Indonesia. *Procedia Environmental Sciences*, *28*(SustaiN 2014), 176–184. DOI: https://doi.org/10.1016/j.proenv.2015.07.024

Arnold, S., Vetter, M., & Dentinho, T. (2017). Bid rents dos modelos de interação espacial com uso do solo na região de Munique. *Revista Portuguesa de Estudos Regionais*, *44*(1), 57–67. Retrieved from http://www.apdr.pt/siterper/numeros/RPER44/44.4.pdf

Arum, S. P., & Fukuda, D. (2020). The impact of railway networks on residential land values within transit-oriented development areas. *Asian Transport Studies*, *6*, 100009. DOI: https://doi.org/10.1016/j.eastsj.2020.100009

Azhdari, A., Sasani, M. A., & Soltani, A. (2018). Exploring the relationship between spatial driving forces of urban expansion and socioeconomic segregation: The case of Shiraz. *Habitat International*, *81*, 33–44. DOI: https://doi.org/10.1016/j.habitatint.2018.09.001

Boamah, N. A. (2013). Land use controls and residential land values in the Offinso South municipality, Ghana. *Land Use Policy*, *33*, 111–117. DOI: https://doi.org/10.1016/j.landusepol.2012.12.016

Brueckner, J. K. (2013). Slums in developing countries: New evidence for Indonesia. *Journal of Housing Economics*, *22*(4), 278–290. DOI: https://doi.org/10.1016/j.jhe.2013.08.001

Davis, M. A., Oliner, S. D., Pinto, E. J., & Bokka, S. (2017). Residential land values in the Washington, DC metro area: New insights from big data. *Regional Science and Urban Economics*, *66*, 224–246. DOI: https://doi.org/10.1016/j.regsciurbeco.2017.06.006

Drake, T. W., Podgorski, D. C., Dinga, B., Chanton, J. P., Six, J., & Spencer, R. G. M. (2020). Land-use controls on carbon biogeochemistry in lowland streams of the Congo Basin. *Global Change Biology*, *26*(3), 1374–1389. DOI: https://doi.org/10.1111/gcb.14889

Dziauddin, M. F. (2019). Estimating land value uplift around light rail transit stations in Greater Kuala Lumpur: An empirical study based on geographically weighted regression (GWR). *Research in Transportation Economics*, *74*, 10–20. DOI: https://doi.org/10.1016/j.retrec.2019.01.003

Elmanisa, A. M., Kartiva, A. A., Fernando, A., Arianto, R., Winarso, H., & Zulkaidi, D. (2016). Land Price Mapping of Jabodetabek, Indonesia. *Geoplanning: Journal of Geomatics and Planning*, *4*(1), 53. DOI: https://doi.org/10.14710/geoplanning.4.1.53-62

Enfoque, E. L., La, I. Y., Unión, L. A., El, E., & La, C. D. E. (2019). Designing the city soud: The bells of Madrid into Hads of Llorenc Barber. *ACE*: *Architecture, City and Environment*, *14*(41), 35–60. DOI: https://doi.org/10.5821/ace.14.41.8697

Forte, Fabian. (2016). New Land Values Patterns in The Space of the Italian Metropolitan Areas: The Case of The Logistic Retro-Port in Naple. *Procedia - Social and Behavioral Sciences*, *223*, 503–508. DOI: https://doi.org/10.1016/j.sbspro.2016.05.308

García-Hípola, M. (2021). Architecture in the expanded field. The concept of landscape in the writings and work of alejandro de la sota. *ACE*: *Architecture, City and Environment*, *15*(45), 1-17. DOI: https://doi.org/10.5821/ace.15.45.8289

Han, W., Zhang, X., & Zheng, X. (2020). Land use regulation and urban land value: Evidence from China. *Land Use Policy*, *92*, 104432. DOI: https://doi.org/10.1016/j.landusepol.2019.104432

Hasanawi, A., & Winarso, H. (2018). Land-Price Dynamics Surrounding Large-Scale Land Development of Technopolis Gedebage, Bandung, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *158*(1). DOI: https://doi.org/10.1088/1755-1315/158/1/012011

E-ISSN 1886-4805

Ichwan, M., Sugeng, Wi., & Brata, A. (2011). *Perancangan Dan Implementasi Prototypesistem Realtime Monitoring Performa Server*. *2*(2), 22–30.

Kim, B., & Kim, T. (2016). A study on estimation of land value using spatial statistics: Focusing on real transaction land prices in Korea. *Sustainability (Switzerland)*, *8*(3), 1–14. DOI: https://doi.org/10.3390/su8030203

Kim, H. S., Lee, G. E., Lee, J. S., & Choi, Y. (2019). Understanding the local impact of urban park plans and park typology on housing price: A case study of the Busan metropolitan region, Korea. *Landscape and Urban Planning*, *184*, 1–11. DOI: https://doi.org/10.1016/j.landurbplan.2018.12.007

Kim, M. (2020). Upzoning and value capture: How U.S. local governments use land use regulation power to create and capture value from real estate developments. *Land Use Policy*, *95*, 104624. DOI: https://doi.org/10.1016/j.landusepol.2020.104624

Kok, N., Monkkonen, P., & Quigley, J. M. (2014). Land use regulations and the value of land and housing: An intra-metropolitan analysis. *Journal of Urban Economics*, *81*, 136–148. DOI: https://doi.org/10.1016/j.jue.2014.03.004

Kuusaana, E. D., & Eledi, J. A. (2015). Customary land allocation, urbanization and land use planning in Ghana: Implications for food systems in the Wa Municipality. *Land Use Policy*, *48*, 454–466. DOI: https://doi.org/10.1016/j.landusepol.2015.06.030

Lavee, D. (2015). Land use for transport projects: Estimating land value. *Land Use Policy*, *42*, 594–601. DOI: https://doi.org/10.1016/j.landusepol.2014.09.020

Lee, B., Chang, H. H., & Wang, S. Y. (2021). Can environmental disamenities increase land values? A case study of manufacturing factories on farmland. *Journal of Cleaner Production*, *279*, 123432. DOI: https://doi.org/10.1016/j.jclepro.2020.123432

Li, H., Wei, Y. D., Yu, Z., & Tian, G. (2016). Amenity, accessibility and housing values in metropolitan USA: A study of Salt Lake County, Utah. *Cities*, *59*, 113–125. DOI: https://doi.org/10.1016/j.cities.2016.07.001

Lu, X., Zhao, M., Liu, K., Zhuo, Q., Fan, J., Yu, Z., & Gong, Y. (2018). Formation condition of deep gas reservoirs in tight sandstones in Kuqa Foreland Basin. In *Petroleum Research, 3*(4), 346–358. DOI: https://doi.org/10.1016/j.ptlrs.2018.11.003

Malaitham, S, Fukuda, A., Vichiensan, V., & Wasuntarasook, V. (2020). Hedonic pricing model of assessed and market land values: A case study in Bangkok metropolitan area, Thailand. *Case Studies on Transport Policy*, *8*(1), 153–162. DOI: https://doi.org/10.1016/j.cstp.2018.09.008

Mazzocchi, C., Corsi, S., & Sali, G. (2017). Agricultural Land Consumption in Periurban Areas: a Methodological Approach for Risk Assessment Using Artificial Neural Networks and Spatial Correlation in Northern Italy. *Applied Spatial Analysis and Policy*, *10*(1), 3–20. DOI: https://doi.org/10.1007/s12061-015-9168-9

Mcgee, T. G. (2009). *The Spatiality of Urbanization : The Policy Challenges of Mega-Urban and Desakota Regions of Southeast Asia* (Issue January). Institute for Environment and Development, Universiti Kebangsaan Malaysia.

Melián-alzola, L., Fernández-monroy, M., & Hidalgo-peñate, M. (2020). Information technology capability and organisational agility: A study in the Canary Islands hotel industry. *Tourism Management Perspectives*, *33*, 1–9. DOI: https://doi.org/10.1016/j.tmp.2019.100606

Mitchell, D., Enemark, S., & van der Molen, P. (2015). Climate resilient urban development: Why responsible land governance is important. *Land Use Policy*, *48*, 190–198. DOI: https://doi.org/10.1016/j.landusepol.2015.05.026

Nascimento, R. L. P., de Andrade Mesquita, I. M., Gondim, R., dos Apóstolos, R. A. A. C., Toralles, M. B., de Oliveira, L. B., Canguçu-Campinho, A. K., & Barroso, U. (2018). Gender identity in patients with 5-alpha reductase deficiency raised as females. *Journal of Pediatric Urology*, *14*(5), 419.e1-419.e6. DOI: https://doi.org/10.1016/j.jpurol.2018.08.021

Paramitadevi, Y. V. (2020). The Issue of Strategic Sustainable Development of Depok City. *Journal Of System Dynamics*, *1*(2), 73–86. Retrieved from https://journal.sysdyn.org/index.php/JSD/article/view/12

Rosa-Jiménez, C., & Nebot, N. (2021). Economic viability of neighborhood cooperatives for active aging. Malaga as a case study | Viabilidad económica de las cooperativas vecinales para el envejecimiento activo. Málaga como caso de estudio. *ACE: Architecture, City and Environment*, *15*(45), 1–13. DOI: https://doi.org/10.5821/ace.15.45.10368

Sharma, R., & Newman, P. (2018). Does urban rail increase land value in emerging cities? Value uplift from Bangalore Metro. *Transportation Research Part A: Policy and Practice*, *117*, 70–86. DOI: https://doi.org/10.1016/j.tra.2018.08.020

Shatkin, G. (2016). The real estate turn in policy and planning: Land monetization and the political economy of peri-urbanization in Asia. *Cities*, *53*, 141–149. DOI: https://doi.org/10.1016/j.cities.2015.11.015

Shi, Q., & Cao, G. (2020). Urban spillover or rural industrialisation: Which drives the growth of Beijing Metropolitan Area. *Cities*, *105*(April), 0–1. DOI: https://doi.org/10.1016/j.cities.2019.05.023

Sly, D. F., & Tayman, J. (1980). Metropolitan morphology and population mobility: the theory of ecological expansion reexamined. *American Journal of Sociology*, *86*(1), 119–138. DOI: https://doi.org/10.1086/227205

Song, Z., Wang, C., & Bergmann, L. (2020). China's prefectural digital divide: Spatial analysis and multivariate determinants of ICT diffusion. *International Journal of Information Management*, *52*(November 2019), 102072. DOI: https://doi.org/10.1016/j.ijinfomgt.2020.102072

Tione, S. E., & Holden, S. T. (2020). Urban proximity, demand for land and land shadow prices in Malawi. *Land Use Policy*, *94*(July 2019), 104509. DOI: https://doi.org/10.1016/j.landusepol.2020.104509

Tsutsumi, M., Shimada, A., & Murakami, D. (2011). Land price maps of Tokyo metropolitan area. *Procedia - Social and Behavioral Sciences*, *21*, 193-202. DOI: https://doi.org/10.1016/j.sbspro.2011.07.046

Tuppen, J. N. (1986). Core periphery in metropolitan development and planning: Socio-economic change in Lyon since 1960. *Geoforum*, *17*(1), 1-37. DOI: https://doi.org/10.1016/0016-7185(86)90009-6

Utami, I. S., Septiyanto, R. F., Wibowo, F. C., & Suryana, A. (2017). Pengembangan STEM-A (Science, Technology, Engineering, Mathematic and Animation) berbasis kearifan lokal dalam pembelajaran Fisika. *Jurnal Ilmiah Pendidikan Fisika Al-BiRuNi*, *06*, 67–73. DOI: https://doi.org/10.24042/jpifalbiruni.v6i1.1581

Vij, S., Narain, V., Karpouzoglou, T., & Mishra, P. (2018). From the core to the periphery: Conflicts and cooperation over land and water in periurban Gurgaon, India. *Land Use Policy*, *76*, 382-390. DOI: https://doi.org/10.1016/j.landusepol.2018.04.050

Walker, R. & Homma, O. (1996). Land use and Land Cover Dynamics in the Brazilian Amazon: an overview. *Ecological Economics*, *18*, 67-75. DOI: https://doi.org/10.1016/0921-8009(96)00033-X

Wheeler, D., & Tiefelsdorf, M. (2005). Multicollinearity and correlation among local regression coefficients in geographically weighted regression. *Journal of Geographical Systems*, *7*(2), 161-187. DOI: https://doi.org/10.1007/s10109-005-0155-6

Winarso, H., Hudalah, D., & Firman, T. (2015). Peri-urban transformation in the Jakarta metropolitan area. *Habitat International*, *49*, 221–229. DOI: https://doi.org/10.1016/j.habitatint.2015.05.024

Wolloch, N. (2020). Adam Smith and the concept of natural capital. Ecosystem Services, 43(July 2019), 101097. DOI: https://doi.org/10.1016/j.ecoser.2020.101097